Claims

What is claimed is:

1. A method of forming an embedded read element, comprising:

performing a photolithographic patterning step for defining a designed height of an embedded read element on a wafer, wherein the definition of the height of the embedded read element also results in formation of an in-line lapping guide with a spacing formed between the embedded read element and the in-line lapping guide;

performing a further photolithographic patterning step for defining a designed width of the embedded read element;

performing a further photolithographic patterning step for connecting the embedded read element and the in-line lapping guide with conducting layers;

performing a first mechanical lapping step on the wafer, wherein the first mechanical lapping step is monitored by measuring the resistance of a parallel circuit of the embedded read element and the in-line lapping guide; and

performing a second mechanical lapping step on the wafer, wherein the second mechanical lapping step is monitored by measuring the GMR response of the embedded read element.

2. A method as recited in claim 1, wherein the read element is an embedded giant magnetoresistance (GMR) sensor used in a current-in-plane (CIP) mode.

3. A method as recited in claim 2, wherein the embedded giant magnetoresistance (GMR) sensor comprises:

a nonmagnetic seed layer;

ferromagnetic sense layers;

a nonmagnetic spacer layer;

a ferromagnetic reference layer;

a nonmagnetic antiparallel (AP) exchange-coupling layer;

a ferromagnetic keeper layer; and

a nonmagnetic cap layer.

4. A method as recited in claim 3, wherein the embedded giant magnetoresistance (GMR) sensor further comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap layers.

5. A method as recited in claim 3, wherein the embedded giant magnetoresistance (GMR) sensor comprises:

a nonmagnetic Ni-Cr-Fe seed layer;

ferromagnetic Ni-Fe/Co-Fe sense layers;

a nonmagnetic Cu-O spacer layer;

a ferromagnetic Co-Fe reference layer;

a nonmagnetic Ru antiparallel (AP) exchange-coupling layer;
a ferromagnetic Co-Fe keeper layer; and
nonmagnetic Cu and Ta cap layers.

6. An embedded GMR sensor as recited in claim 5, further comprising an antiferromagnetic Pt-Mn pinning layer sandwiched into the Co-Fe keeper and Cu cap layers.

7. A method as recited in claim 1, wherein the read element is an embedded giant magnetoresistance (GMR) sensor used in a current-perpendicular-to-plane (CPP) mode.

8. A method as recited in claim 7, wherein the embedded giant magnetoresistance (GMR) sensor comprises:
a nonmagnetic seed layer;
ferromagnetic sense layers;
a nonmagnetic spacer layer;
a ferromagnetic reference layer;
a nonmagnetic antiparallel (AP) exchange-coupling layer;
a ferromagnetic keeper layer; and
a nonmagnetic cap layer.

9. A method as recited in claim 8, wherein the embedded GMR sensor further comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap layers.

10. A method as recited in claim 7, wherein the embedded GMR sensor comprises:
a nonmagnetic seed layer;
ferromagnetic sense layers;
a nonmagnetic spacer layer;
a ferromagnetic reference layer;
a nonmagnetic antiparallel (AP) exchange-coupling layer;
a ferromagnetic keeper layer; and
a nonmagnetic cap layer.

11. A method as recited in claim 10, wherein the embedded GMR sensor further comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap layers.

12. A method as recited in claim 1, wherein the read element is an embedded tunneling magnetoresistance (TMR) sensor used in a current-perpendicular-to-plane (CPP) mode.

13. A method as recited in claim 12, wherein the embedded TMR sensor comprises:
a nonmagnetic seed layer;

ferromagnetic sense layers;
a nonmagnetic barrier layer;
a ferromagnetic reference layer;
a nonmagnetic antiparallel (AP) exchange-coupling layer;
a ferromagnetic keeper layer; and
a nonmagnetic cap layer.

14. A method as recited in claim 13, wherein the embedded TMR sensor further comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap layers.

15. An embedded read element as recited in claim 12, which is an embedded tunneling magnetoresistance (TMR) sensor used in a current-perpendicular-to-plane (CPP) mode, comprising:
a nonmagnetic Ta seed layer;
ferromagnetic Ni-Fe/Co-Fe sense layers;
a nonmagnetic Al-O barrier layer;
a ferromagnetic Co-Fe reference layer;
a nonmagnetic Ru antiparallel (AP) exchange-coupling layer;
a ferromagnetic Co-Fe keeper layer; and
nonmagnetic Cu and Ta cap layers.

16. A method of forming an embedded read element, comprising:

performing a photolithographic patterning step for defining a designed height of an embedded read element on a wafer, wherein the definition of the height of the embedded read element also results in formation of an in-line lapping guide with a spacing formed between the embedded read element and the in-line lapping guide;

performing a further photolithographic patterning step for defining a designed width of the embedded read element;

performing a first mechanical lapping step on the wafer; and

performing a second mechanical lapping step on the wafer.

17. A method as recited in claim 16, further comprising performing a further photolithographic patterning step for connecting the embedded read element and the in-line lapping guide with conducting layers;

18. A method as recited in claim 16, wherein the first mechanical lapping step is monitored by measuring the resistance of a parallel circuit of the embedded read element and the in-line lapping guide.

19. A method as recited in claim 16, wherein the second mechanical lapping step is monitored by measuring the GMR response of the embedded read element.

20. An embedded read element, comprising:

a read element having been formed according to the following method:

performing a photolithographic patterning step for defining a designed height of an embedded read element on a wafer, wherein the definition of the height of the embedded read element also results in formation of an in-line lapping guide with a spacing formed between the embedded read element and the in-line lapping guide;

performing a photolithographic patterning step for defining a designed width of the embedded read element;

performing a further photolithographic patterning step for connecting the embedded read element with conducting layers;

performing a first mechanical lapping step on the wafer, wherein the mechanical lapping step is monitored by measuring the resistance of a parallel circuit of the embedded read element and the in-line lapping guide;

performing a second mechanical lapping step on the wafer, wherein the second mechanical lapping step is monitored by measuring the GMR response of the embedded read element.

21. A magnetic disk drive, comprising:

a magnetic disk;

a slider having a magnetic head assembly including write and read heads for writing to and reading data from the magnetic disk is mounted, wherein the read head includes an embedded read element formed by the process recited in claim 1;

a suspension arm supporting the slider; and

an actuator arm coupled to the suspension arm.